

1

SPREAD SPECTRUM ADAPTIVE POWER CONTROL COMMUNICATIONS SYSTEM AND METHOD

CROSS-REFERENCES TO RELATED APPLICATIONS

This patent is a continuation application of U.S. Pat. application No. 08/666,069, filed Jun. 21, 1996, now abandoned which is a continuation application of U.S. Pat. application No. 08/218,198, filed Mar. 28, 1994, now U.S. Pat. No. 5,535,238, which is a continuation-in-part application of U.S. Pat. application No. 07/792,869, filed Nov. 19, 1991, now U.S. Pat. No. 5,299,226 which is a continuation-in-part of U.S. Pat. application No. 07/614,816, filed Nov. 16, 1990, now U.S. Pat. No. 5,093,840.

BACKGROUND OF THE INVENTION

This invention relates to spread-spectrum communications, and more particularly to an apparatus and method for adaptive power control of a spread-spectrum signal in a cellular, personal communications environment.

DESCRIPTION OF THE PRIOR ART

A spread-spectrum signal typically is generated by modulating an information-data signal with a chip-code signal. The information-data signal may come from a data device such as a computer, or an analog device which outputs an analog signal which has been digitized to an information-data signal, such as voice or video. The chip-code signal is generated by a chip-code where the time duration, T_c , of each chip is substantially less than a data bit or data symbol.

Spread-spectrum modulation provides means for communicating in which a spread-spectrum signal occupies a bandwidth in excess of the minimum bandwidth necessary to send the same information. The band spread is accomplished using a chip code which is independent of an information-data signal. A synchronized reception with the chip-code at a receiver is used for despreading the spread-spectrum signal and subsequent recovery of data from the spread-spectrum signal.

Spread-spectrum modulation offers many advantages as a communications system for an office or urban environment. These advantages include reducing intentional and unintentional interference, combating multipath problems, and providing multiple access to a communications system shared by multiple users. Commercially, these applications include, but are not limited to, local area networks for computers and personal communications networks for telephone, as well as other data applications.

A cellular communications network using spread-spectrum modulation for communicating between a base station and a multiplicity of users, requires control of the power level of a particular mobile user station. Within a particular cell, a mobile station near the base station of the cell may be required to transmit with a power level less than that when the mobile station is near an outer perimeter of the cell. This is done to ensure a constant power level at the base station, received from each mobile station.

In a first geographical region, such as an urban environment, the cellular architecture within the first geographical region may have small cells which are close to each other, requiring a low power level from each mobile user. In a second geographical region, such as a rural environment, the cellular architecture within the region may have large cells which are spread apart, requiring a relatively

2

high power level from each mobile user. A mobile user who moves from the first geographical region to the second geographical region typically adjusts the power level of his transmitter, for meeting the requirements of a particular geographic region. Otherwise, if the mobile user traveled from a sparsely populated region with fewer spread out cells using the relatively higher power level with his spread-spectrum transmitter, to a densely populated region with many cells, without reducing the power level of his spread-spectrum transmitter, his spread-spectrum transmitter may cause undesirable interference within the cell in which he is located and/or to adjacent cells. Also, if a mobile user moves behind a building and has his signal to the base station blocked by the building, then the mobile user's power level should be increased. And doing this quickly, with high dynamic range and in a manner to ensure an almost constant received power level with low root mean square error and peak deviations from this constant level.

Accordingly, there is a need to have a spread-spectrum system and method for automatically controlling a mobile user's spread-spectrum transmitter power level when operating in a cellular communications network.

SUMMARY OF THE INVENTION

A general object of the invention is a system and method which results in maximization of user density within a cell domain while minimizing mobile user transmitted power.

An object of the invention is to provide an apparatus and method which controls the power level of a mobile station so that the power level received at the base station of each cell is the same for each mobile station.

Another object of the invention is to provide a system and method for automatically and adaptively controlling the power level of a mobile user in a cellular communications network.

A further object of the invention is to provide a spread-spectrum system and method which allows operating a spread-spectrum transmitter in different geographic regions, wherein each geographic region has a multiplicity of cells, and cells within a geographic region may have different size cells and transmitter power requirements.

According to the present invention, as embodied and broadly described herein, a system for adaptive-power control (APC) of a spread-spectrum transmitter is provided. A plurality of mobile stations operate in a cellular-communications network using spread-spectrum modulation. A mobile station transmits a first spread-spectrum signal. The base station transmits a second spread-spectrum signal.

The base station includes automatic gain control (AGC) means, base-correlator means, power means, transmitter means, and an antenna. The base-correlator means is coupled to the AGC means. The power means is coupled to the base-correlator means and to the comparator means. The comparator means is coupled to the power means. The antenna is coupled to the transmitter means.

Each mobile station includes despreading means and variable-gain means.

A received signal is defined herein to include the first spread-spectrum signal and an interfering signal. The interfering signal is defined herein to include a noise and/or other spread-spectrum signals and/or other undesirable signals which are coexistent in frequency with the first spread-spectrum signal.

For each received signal, the AGC means generates an AGC-output signal. The base-correlator means despreads